

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

APPLICATION FOR UTILITY PATENT

TITLE

DRY ICE BLOCK EXTRUDER

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BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

This invention relates generally to the manufacture of dry ice and, more particularly, to a method and apparatus for producing slabs or blocks of dry ice.

2. BACKGROUND INFORMATION

Solid state carbon dioxide (CO₂), known as dry ice, is used in many different applications. Dry ice is ideal for preserving food because it sublimates directly from its solid phase to its gaseous phase, leaving no odor, color, taste, or residue and causes no deleterious effects to the food. In cooling and preserving food, dry ice pellets may be placed directly onto the food to rapidly cool it below some specified temperature to prevent spoilage.

Dry ice has traditionally been produced and distributed in blocks with each block weighing about 55 pounds. The blocks are cumbersome, expensive and require extra effort to crush or break apart to make the dry ice easy to use by reducing the block to reasonable size pieces. In recent years, dry ice has been produced in pellet form, which pellets are much easier to use.

A dry ice pelletizer that is made by Tomco Equipment Co. is shown in U.S. Patent No. 4,780,119, to Brooke, where liquid CO₂ is injected into a chamber known as an extrusion chamber and flashed at atmospheric pressure. In this flashing process, part of the liquid CO₂ changes phase to a solid known as "snow," with the

1 remaining part of the liquid CO₂ changing phase to gas. The gaseous CO₂ can exit
2 the extrusion chamber through gas vents and the remaining snow may be
3 compressed at the end of the extrusion chamber. The proportionate amount of the
4 gaseous CO₂ versus the snow depends upon the pressure and temperature of the
5 liquid CO₂ that is fed into the extrusion chamber and the surrounding pressure and
6 temperature of the extrusion chamber. The lower the pressure and temperature, the
7 greater the amount of snow produced in the flashing process.

8 When liquid CO₂ is flashed under ideal conditions at atmospheric pressure,
9 approximately 48% of the liquid CO₂ is changed to snow, while approximately 52% of
10 the liquid CO₂ is changed to gas. Because the percentage of snow formation is
11 directly proportional to the pressure inside the extrusion chamber, when flashing
12 occurs, it is important that the pressure inside the extrusion chamber be kept as
13 close to atmospheric pressure as possible.

14 Once the snow is formed in the extrusion chamber, a piston is used to
15 compact the snow in one end of the extrusion chamber against a die. In the
16 traditional pelletizer, the snow will collect in the openings of the die and before long
17 block the openings. While some small amount of snow may escape, it is not that
18 significant. Thereafter, when the pistons move back and forth to compress the snow,
19 the snow is compressed at the end against the die to form what is called a puck. As
20 additional dry ice (i.e., snow) is compressed against the puck, the puck will extrude

1 through the openings in the die.

2 For some applications, the use of pelletized dry ice is not the ideal situation.

3 For example, in some occasions, blocks or slabs of dry ice are much better than
4 pellets of dry ice. However, the 55 pound blocks of dry ice are normally much larger
5 than desired. Sometimes it is necessary to cut the blocks of dry ice into other shapes
6 or sizes, such as shown in U.S. Patent No. 5,189,939, to Allen. However, when the
7 blocks of dry ice are cut, there is attendant waste in the cutting process.

8 As an example of an industry that uses smaller blocks or slabs of dry ice, the
9 airline industry uses thousands of pounds of dry ice per day to keep food cool in their
10 serving carts. At the bottom of the serving cart is a tray located a block or slab of dry
11 ice that is approximately 1" x 5" x 5". In other words, the 55 pound block would have
12 to be cut into small slabs of dry ice that can be put in the tray in the bottom of the
13 serving cart for the airline industry. This small slab of dry ice will then sublime
14 directly from the solid to gaseous state leaving no odor and no deleterious effects
15 while keeping the food cool. The airline industry uses large amounts of dry ice per
16 day for this particular purpose.

17 Slabs or blocks of dry ice could be used for many other purposes other than in
18 the airline industry. Anytime there is a necessity to keep something cool for a period
19 of time in which there is no residue to be dealt with during or after cooling, dry ice
20 becomes an ideal candidate because it sublimates from solid to gaseous state, which

gaseous state has no adverse effects.

If smaller blocks or slabs of dry ice can be formed directly from liquid CO₂, the losses attendant with cutting of large blocks of dry ice would not occur. The present invention is designed to solve this problem by providing for the extrusion of smaller blocks or slabs of dry ice that can be used in many different applications. None of the devices known by applicant allow for direct extrusion of blocks of dry ice, which blocks could be used by an end user, such as the airline industry.

SUMMARY OF THE INVENTION

A conventional dry ice pelletizer is used, which consists of a cylinder in which liquid CO₂ is introduced through an injection port for flashing to form gaseous CO₂ and solid CO₂ therein. The gaseous CO₂ is vented and a piston is used to compress any solid CO₂ (snow) that forms in the chamber into a single mass of dry ice at one end of the cylinder, which mass of dry ice is known as a puck. For traditional pelletizers, the openings in the die quickly fill up with snow that blocks the openings. Then the snow is compressed against the die with each stroke of the piston. Ultimately, the piston pushes against the snow and puck with sufficient pressure to force the solidified CO₂ out the openings in the die as a continuous rod of dry ice. Periodically, the rod of dry ice is broken off into pellets.

In the present invention, the die has been changed. In the die, there is a large slot with 1" x 5" being a typical size slot. If nothing is done to block the slot, the

1 CO₂, either in the gaseous state or as snow, will simply escape through the slot. To
2 prevent that from occurring, a gate is moved over the slotted opening. The gate, once
3 in place, prevents CO₂ either in the gaseous state or solid state of snow from
4 escaping from the compression chamber. Now as a piston moves back and forth with
5 the introduction of liquid CO₂, the snow begins to compress against the die. Once a
6 puck is formed against the die, then the gate can be removed. Thereafter, as the
7 piston continues to reciprocate inside the cylinder with the introduction of liquid CO₂
8 that flashes to a combination of gaseous CO₂ and snow, the snow is compressed
9 against the puck, and the puck is extruded through the die. If the slot in the die is
10 approximately 1" x 5", the extruded dry ice will have a cross-sectional area of
11 approximately 1" x 5".

12 Immediately upon passing through the die, the 1" x 5" slab of dry ice has not
13 set up into a good solid form. Therefore, an additional distance known as a forming
14 chamber will be located adjacent to the die. The forming chamber may be a part of
15 the die or a separate item attached thereto. Typically, the forming chamber would be
16 approximately 2 inches thick.

17 As the extrusion process continues and the 1" x 5" slab of dry ice is extruded,
18 at some time the slab of dry ice will reach a desired length. A sensing device, such as
19 a photocell, would be used to indicate the desired length of the slab has been
20 reached. Assuming the desired length is 6 inches, once the extruded 1" x 5" cross-

1 section of dry ice reaches 6 inches, the photocell will send a signal back indicating
2 the desired length has been reached. That signal can then be used to activate a
3 sizing cylinder that will move a sizing block that breaks off the extruded dry ice into
4 slabs of approximately 1" x 5" x 6" size. The sizing block can be controlled by any
5 type of actuation device that has sufficient strength and speed, but in the present
6 process, a pneumatic cylinder is probably ideal. Therefore, a pneumatic sizing
7 cylinder would move a sizing block that would break off the extruded dry ice into
8 desired lengths.

9 Since liquid CO₂ is continuously being fed to the extrusion chamber for
10 compression by the piston, snow continues to compress and the rectangular shaped
11 cross-sectional area continues to be extruded. The next time the rectangular shaped
12 extruded dry ice reaches the desired length, the process is repeated again. By
13 repeatedly using this process, numerous blocks or slabs of dry ice of the desired
14 dimensions are formed without the necessity for sawing or cutting.

15 The gate only needs to be used during startup of the extrusion process. At
16 that time, some force needs to hold the gate against the die. That force of holding
17 the gate against the die may be provided by any of a number of different means,
18 including a track that would force the gate against the outside of the die. On the
19 other hand, the sizing block does not need the force to push it against the die
20 because all the sizing block is doing is breaking off the extruded rectangular section

1 of dry ice.

2 It is an object of the present invention to provide a device for extruding blocks
3 or slabs of dry ice.

4 It is another object of the present invention to provide a dry ice extruder that
5 can automatically extrude blocks or slabs of dry ice.

6 It is yet another object of the present invention to modify a dry ice extruder to
7 have a die that will extrude a rectangular shaped slab of dry ice, which slab may be
8 broken upon reaching a predetermined length.

9 It is another object of the present invention to provide a die with a slot therein
10 for extruding a rectangular cross-section of dry ice, which slot is blocked during
11 startup of the extruder to allow for the building of a puck of dry ice therein.

12 It is still another object of the present invention to provide a dry ice extruder
13 for extruding a slab of dry ice, which slab may be broken into predetermined lengths,
14 the process being automated for blocking the slot in the die upon startup and
15 thereafter to actuate a sizing device for breaking the extruded slab into
16 predetermined lengths.

17 These and other objects of the present invention are met when practicing the
18 method or device as described hereinbelow.

19 **BRIEF DESCRIPTION OF THE DRAWINGS**

20 FIG. 1 is a perspective view of a Tomco type dry ice extruder which has been

1 modified to extrude blocks or slabs of dry ice in accordance with the present
2 invention.

3 FIG. 2 is an exploded perspective view of the extrusion cylinder portion of the
4 dry ice extruder, including the die, forming chamber, gate and sizing device.

5 FIG. 3 is an elevated end view of the die on the dry ice extruder.

6 FIG. 4 is an elevated partial cross-sectional view of FIG. 3 showing the
7 extrusion cylinder on the dry ice extruder showing the die, forming chamber, gate
8 and sizing device.

9 FIG. 5 is a simplified schematic diagram indicating hydraulic, pneumatic and
10 liquid CO₂ supply systems for the dry ice extruder.

11 DESCRIPTION OF THE PREFERRED EMBODIMENT

12 FIG. 1 shows a commercially available, widely used, dry ice extruder 10 that
13 has been modified from a pelletizer to extrude blocks or slabs of dry ice. The dry ice
14 extruder 10 is commercially available for purchase without the modifications from
15 companies, such as Tomco Equipment Company. Initially hereinbelow, the items
16 commercially available through Tomco or some other supplier will be described
17 before describing the modifications that constitute the present invention. Because
18 dry ice extruders are widely available in the marketplace, dry ice extruder 10 will only
19 be described generally hereinbelow.

20 Dry ice extruder 10 has a pair of side-by-side extrusion cylinders 12 that are

1 operated by a pair of side-by-side hydraulic cylinders 14. The hydraulic cylinders 14
2 are separated from the extrusion cylinders 12 by a spreader box 16. Extrusion
3 cylinders 12, hydraulic cylinders 14, and spreader box 16 are all mounted on frame
4 18, as well as other components that will be described hereinbelow.

5 To operate dry ice extruder 10, liquid CO₂ is delivered to extrusion cylinders
6 12 through liquid CO₂ feed hoses 20 from a source of liquid CO₂ (not shown). Feed
7 hoses 20 feed liquid CO₂ into extrusion cylinders 12 through injection connectors 22.
8 Inside of extrusion cylinders 12, the liquid CO₂ is flashed so a portion thereof forms
9 gaseous CO₂ and the remainder forms solid CO₂ in what is commonly called "snow."
10 The gaseous CO₂ is vented or removed from the extrusion cylinders 12 (see FIG. 2)
11 and the snow compacted or compressed by piston 24 (see FIG. 2) as will
12 subsequently be explained.

13 To operate piston 24 inside of extrusion cylinders 12, hydraulic cylinder 14 is
14 connected via hydraulic hoses 26 through a pump (not shown) to a reservoir of
15 hydraulic fluid 28. A control box 30 controls the operation of the dry ice extruder 10
16 with motor controller 32 receiving commands from connection 34 to spreader box 16
17 and from control box 30. Hydraulic hoses 26 are connected through fittings 36 to
18 deliver hydraulic fluid to and from hydraulic cylinders 14.

19 Extrusion cylinders 12 are connected on one end of spreader box 16 through
20 extrusion flange 38, while hydraulic cylinders 14 are connected on the opposite end

1 of spreader box 16 by hydraulics flange 40.

2 The parts described in the foregoing Description of the Preferred Embodiment
3 are old and can be found in a Tomco extruder. The portions described hereinbelow
4 are what is new and added by the present invention.

5 Referring to FIG. 2 now in combination with FIG. 1, extrusion cylinders 12 are
6 held together by four prestressed rods 42 that connect from extrusion flange 38,
7 around extrusion cylinders 12, through die holder 44, die 46, and forming chamber
8 48, and extend there beyond. On one end, the prestressed rods 42 can end at the
9 extension flange 38 of spreader box 16, or they may extend therethrough to hold
10 together hydraulic cylinders 14 and end with hydraulic flange 50 (see FIG. 1).

11 While it may not be immediately clear upon viewing FIG. 1, the dry ice
12 extruder 10 is a dual system with two extrusion cylinders 12 and two hydraulic
13 cylinders 14 being side by side. The operation of extrusion cylinders 12 alternates
14 with piston 24 being retracted by piston rod 52 (see FIG. 2) in the first extrusion
15 cylinder 12 and extended in the second extrusion cylinder 12. This operation is
16 controlled by hydraulic cylinders 14, alternately extending and retracting piston rods
17 52 connected to pistons 24 in the side-by-side extrusion cylinders 12. This
18 alternating type of compression and retraction provides balance to dry ice extruder
19 10, so it will operate much smoother. Because extrusion cylinders 12 are identical,
20 only one extrusion cylinder 12, along with die holder 44, die 46, forming chamber 48,

1 and the controls associated therewith, will be explained in detail.

2 Prestressed rods 42 extend through holes 54 of die holder 44 and notches 56
3 in die 46. Nuts 58 thread onto the prestressed rods 42 to clamp the inner lip 60 of
4 the die holder 44 around cylinder 62 of extrusion cylinders 12. Forming chamber 48
5 can be made either integral with die 46 or may be bolted thereto by recessed bolt 68.
6 Die 46 is also held to die holder 44 by bolts 64 connecting into holes 66. In the
7 center of die 46 is an extruding slot 70, through which dry ice may be extruded. The
8 dry ice feeding through extruding slot 70 has not yet formed, so forming slot 72 in
9 forming chamber 48 will give the dry ice sufficient time to form and harden prior to
10 being exposed to atmosphere.

11 In typical operation, liquid CO₂ from a suitable source would be injected into
12 cylinder 62 of extrusion cylinder 12 through feed hoses 20 and injection connectors
13 22. Inside of cylinder 62, the liquid CO₂ will be flashed to atmospheric pressure
14 thereby forming gaseous CO₂ and solid CO₂ in the form of snow. The gaseous CO₂
15 will be vented to either atmosphere or a gaseous CO₂ collection system through vent
16 holes 74. Pressure port 76 on cylinder 62 is used to monitor the pressure inside of
17 cylinder 62 through either a pressure gauge 78 (see FIG. 1) or by appropriate
18 feedback to control box 30. Depending upon the pressure inside of cylinder 62, the
19 amount of liquid CO₂ being injected or the repetition rate of piston 24 can be varied.

20 To prevent the gaseous CO₂ and the solid CO₂ (snow) from escaping through
21 extruding slot 70 and forming slot 72 to atmosphere, something must block slots 70

1 or 72. In the present invention, a mounting plate 80 is bolted onto prestressed rods
2 42 by nuts 82. (See FIGs. 3 and 4 in combination with FIGs. 1 and 2.) Mounting
3 plate 80 is located along the prestressed rods 42 so that gate 84 and sizing block 86
4 are flush with an outer surface 88 of the forming chamber 48. Mounted on the
5 mounting plate 80 is a sizing cylinder 90 for operating the sizing block 86. Also
6 mounted on mounting plate 80 is a gate cylinder 92 for operating gate 84.

7 On the ends of prestressed rods 42 is located an end plate 94 on which a
8 photocell 96 is located. The photocell 96 may be adjusted inward or outward by
9 adjusting slotted rod 98 and screw 100.

10 In actual operation, when someone starts the dry ice extruder 10, liquid CO₂
11 comes in through feeder hoses 20 from a source of liquid CO₂ (not shown) into
12 cylinder 62 of extrusion cylinders 12. The liquid CO₂ is flashed to gaseous CO₂ and to
13 solid CO₂ (snow) inside of cylinder 62. The gaseous CO₂ is removed through vent
14 holes 74. At this time, the forming slot 72 of the forming chamber 48 should be
15 blocked by gate 84. Gate 84 may either be a manual operation of physically bolting a
16 plate over forming slot 72 or may be an automatic gate 84 that is moved into place by
17 gate cylinder 92. Gate 84 should be pressed tightly against the outer surface 88 of
18 the forming chamber 48 by any convenient means, such as tracks (not shown), that
19 press gate 84 tightly over forming slot 72.

20 As liquid CO₂ is continually flashed inside cylinder 62 while piston 24 is

operating therein via hydraulic cylinders 14, the extrusion cylinder 12 will be cooled down. With the cooling of extrusion cylinder 12, snow will begin to accumulate therein and be pushed against die 46 at the end of cylinder 62. Further accumulation of snow (solidified CO₂) will further consolidate to form a puck at the die end of cylinder 62. The puck once sufficiently solidified and formed, it is now time for extruding cylinder 12 to start extruding dry ice. Therefore, gate cylinder 92 retracts gate 84 to allow solid dry ice to be pushed through extruding slot 70 of die 46 and formed or hardened in forming slot 72 of forming chamber 48. Thereafter, solidified dry ice in slab form is extruded out through extruding slot 70 and forming slot 72. Extruding slot 70 has the normal amount of taper as is normally used for extruding dry ice. Typically there is an approximately 1° taper in both extruding slot 70 and forming slot 72.

As the slab of dry ice continues to be extruded through extruding slot 70 and formed in forming slot 72, at some point the slab of extruded dry ice will reach a desired length. In the present invention, photocell 96, which is mounted on end plate 94, may be adjusted to determine that length. Assume photocell 96 is set to give a signal to control box 30 via connection 102 when the slab of extruded dry ice reaches a predetermined length. The signal being fed back to control box 30 via connection 102 from photocell 96 will actuate the sizing cylinder 90 that moves sizing block 86 against the dry ice to break off the slab of dry ice that has been

1 extruded. Assuming photocell 96 is set for 6 inches, the extruded slab of dry ice will
2 be approximately 6 inches long.

3 While different types of actuating devices may be used to move gate 84 or
4 sizing block 86, in the preferred embodiment the sizing cylinder 90 and gate cylinder
5 92 are pneumatically operated. The pneumatic pressure may be provided by
6 pneumatic pressure in the facility or can be from gaseous CO₂ that has been formed.
7 Even a hydraulic cylinder can be used for gate cylinder 92, but typically a hydraulic
8 cylinder would be too slow for the sizing cylinder 90. Sizing cylinder 90 must be
9 fairly rapid in operation to break off the extruded slab of dry ice while the extrusion
10 process continues. Electrical solenoids can be used in place of sizing cylinder 90 and
11 gate cylinder 92. Assuming pneumatic pressure is used in sizing cylinder 90 and
12 gate cylinder 92, the supply lines 104 (see FIG. 1) are connected to a suitable source
13 of pneumatic pressure (not shown).

14 Referring now to FIG. 5, a schematic illustration as to the operation of the dry
15 ice extruder 10 is illustrated in a schematic diagram. Where appropriate, like
16 numbers will be utilized the same as numbers previously used hereinabove.

17 Hydraulic fluid 28 is pumped by pump 106 through control valve 108 to
18 extrusion cylinders 112 in an alternating manner. In other words, as piston 24 (not
19 shown in FIG. 5) is compressing in one extrusion cylinder 112, the piston 24 is
20 retracting in the other extrusion cylinder 112. Control valve 108 acts as a double-

1 pole, double-throw electrical switch except control valve 108 is controlling the
2 direction of fluid flow rather than current. From control valve 108, fluid is returned
3 through return line 110 to the reservoir for hydraulic fluid 28.

4 On the other end of extrusion cylinder 112, the liquid CO₂ is introduced
5 through CO₂ lines 114 via control valve 116 from liquid CO₂ reservoir 118. Inside of
6 extrusion cylinder 112, the liquid CO₂ is flashed to form gaseous CO₂ and solid CO₂
7 (snow). The gaseous CO₂ is vented through vents 120, either to atmosphere or to a
8 gaseous CO₂ collection system.

9 On the end of the extrusion cylinder 112 is mounted a die 122, followed by
10 forming chamber 124. Initially, when starting the operation, gate actuator 126
11 moves a gate (not shown) to block the extruding slot (not shown) through die 122
12 and forming chamber 124. In this illustrative embodiment, gate actuator 126 is a
13 pneumatic cylinder operated by gate valve 128, which receives pressurized air from
14 pressurized air source 130. After the extrusion cylinder 112 has operated for a
15 sufficient length of time to form a puck at the die end thereof, gate valve 128
16 operates gate actuator 126 to move the gate (not shown) from blocking the extrusion
17 slot (not shown in FIG. 5, but previously explained in connection with FIGs. 1-4).
18 Thereafter, dry ice is extruded in slab form through die 122 and forming chamber
19 124. However, once the dry ice reaches a predetermined length, the extruded slab of
20 dry ice will be sensed by photocell 132, which will send a signal to sizing valve 134.

1 Sizing valve 134, which receives pneumatic pressure from pressurized air source
2 130, will deliver pressurized air to sizing cylinder 136. Sizing cylinder 136 will
3 actuate sizing block 138, which will be pressed against the extruded slab of dry ice
4 causing the slab to break off at the face of forming chamber 124. The actuation of
5 sizing cylinder 136, causing the movement of sizing block 138, is fairly rapid because
6 the extrusion process continues without interruption. In other words, sizing block
7 138 is moved downward to break the extruded slab of dry ice and retracted in a fairly
8 rapid manner. The extrusion process continues uninterrupted until again photocell
9 132 senses the end of the extruded slab of dry ice to again operate the control valve
10 134 to actuate the sizing cylinder 136 and move sizing block 138.

11 In this manner, continual slabs of dry ice are extruded that will have a
12 predetermined thickness, width and length. The length is controlled by adjustment
13 of photocell 132, with the width and thickness determined by the size of the slot in
14 die 122 and forming chamber 124.

15 While in the preferred embodiment it is envisioned the extruded slabs of dry
16 ice would be approximately 1" x 5" x 5", different dimensions can be extruded with
17 the equipment currently available on the market today. It is envisioned that current
18 equipment could extrude slabs of dry ice as thick as 2 inches and as wide as
19 5 inches without significant modification. The length can be any length desired, but
20 a 5 inch length is what is typically used in the airline industry. Depending upon how

the slab or block of dry ice is to be used, the length of the slab or block can be changed very quickly. If other dimensions are desired to be changed, simply by changing the die, the other dimensions can also be changed.

Initially, the gate that blocks the extruding slot, because it only needs to be used once at the beginning of the extrusion process, could be set up by any of a number of different means, including even the bolting of a blank plate on the end of the forming chamber and removing the blank plate once the puck has been formed.